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Wisconsin's Forest Resources in 2000

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ABSTRACT.—The North Central Research Station's Forest Inventory and Analysis program began fieldwork for the sixth forest inventory of Wisconsin in 2000. This initiates a new annual inventory system. This Research Note contains estimates of Wisconsin's forest resources derived from data gathered during the first year of the inventory.

KEY WORDS: Annual inventory, forest land, forest type, growing-stock volume, Wisconsin.

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BACKGROUND

The North Central Research Station's Forest Inventory and Analysis (NCFIA) program began fieldwork for the sixth forest inventory of Wisconsin in 2000, in partnership with the Wisconsin Department of Natural Resources. This inventory initiates a new annual inventory system in the State. One-fifth of the field plots in the State are measured each year under this system. As a result, the current inventory of Wisconsin's forest resources will not be fully implemented until 2005. However, because each year's sample is a systematic sample of the State's forest and because timely information is needed about Wisconsin's forest resources, estimates have been prepared from data gathered during the first year of the inventory. **Due to the limited number of field plots measured, future estimates using data from this report are subject to change when ensuing annual inventories are completed and data compiled.** The results presented are estimates based on sampling techniques. As additional inventories are completed, the precision of the estimates will increase and additional data will be released.

Reports of previous inventories of Wisconsin are dated 1936, 1956, 1968, 1983, and 1996. Data from new inventories are often compared with data from earlier inventories to determine trends in forest resources. However, for the comparison to be valid, the procedures used in the two inventories must be similar. As a result of our ongoing efforts to improve the efficiency and reliability of the inventory, several changes in procedures and definitions have occurred since the last inventory of Wisconsin in 1996 (Schmidt 1998). Some of these changes make it inappropriate to directly compare portions of the 2000 data with data published for 1996.

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RESULTS

Before European settlement, forests occupied an estimated 26.5 million acres or about 76 percent of the land in Wisconsin (Smith *et al.* 2001). Between initial settlement and the first inventory of Wisconsin's forests in 1936, the area of forest land declined by about 36 percent to about 16.9 million acres because of the expansion of agricultural lands, rural communities, small towns, and cities in the State. This downward trend continued between 1936 and 1968 as Wisconsin's forested area decreased by 9 percent, or by about 2 million acres, to 14.9 million acres. This trend reversed between 1968 and 1983 when the area of forest increased by over 400 thousand acres, or by about 3 percent, because of changing agricultural practices that allowed some marginal farmland to revert back to forest. The trend continued between 1983 and 1996 as the area of forest land increased by about 4 percent to 16.0 million acres. Since 1996, the area of forest has decreased slightly to 15.7 million acres and occupies about 45 percent of the State's land area.

The area of timberland, forest land that can produce repeated crops of timber and that is not withdrawn from timber cutting by regulatory action, follows the same trend (fig. 1). Between 1936 and 1956, timberland area in

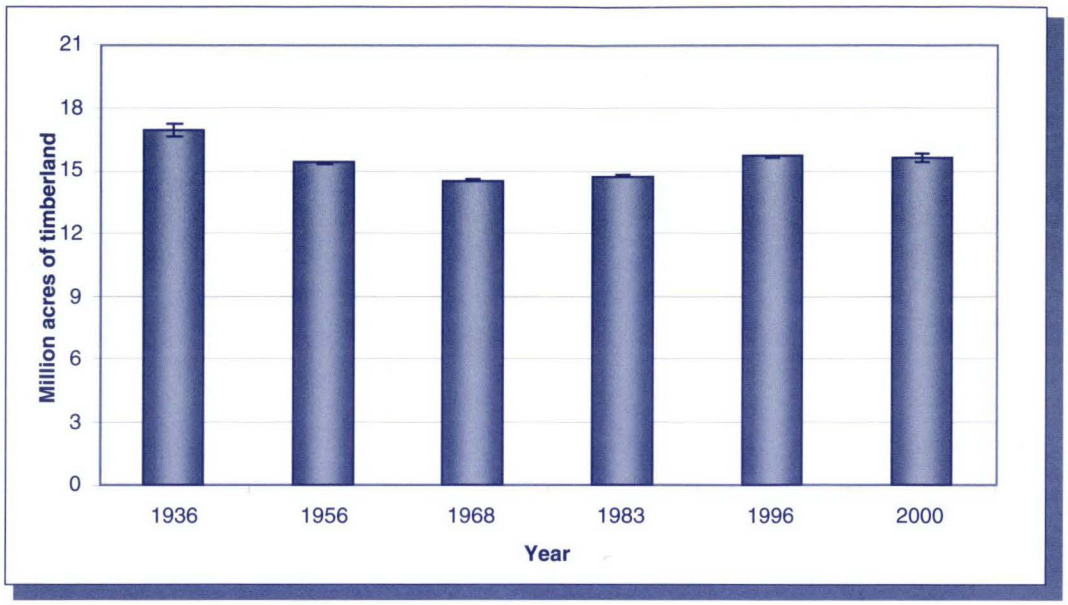

Figure 1.—*Area of timberland in Wisconsin by inventory year (Note: the sample error associated with each inventory is represented by the vetical line at the top of each bar).*

Wisconsin decreased by about 9 percent to 15.4 million acres. Timberland continued to decrease between 1956 and 1968 until it occupied about 42 percent of the State. However, between 1968 and 1983 the area of timberland increased by a little over 1 percent or by about 220 thousand acres. From 1983 to 1996, timberland area increased by about 6 percent. Timberland area in Wisconsin has remained fairly stable since 1996 at a level slightly higher than 1956.

Maple-beech-birch continued as the major forest type group in Wisconsin and occupied about 33 percent of the timberland area in 2000 (fig. 2). The aspen-birch group occurred on about 22 percent of the timberland area and the oak-hickory type group covered 18 percent. Elm-ash-cottonwood occurred on about 10 percent of the State's timberland. Combined, the white pine-jack pine-red pine and spruce-fir type groups covered about 16 percent. Other forest types occurred on less than 1 percent of Wisconsin's timberland.

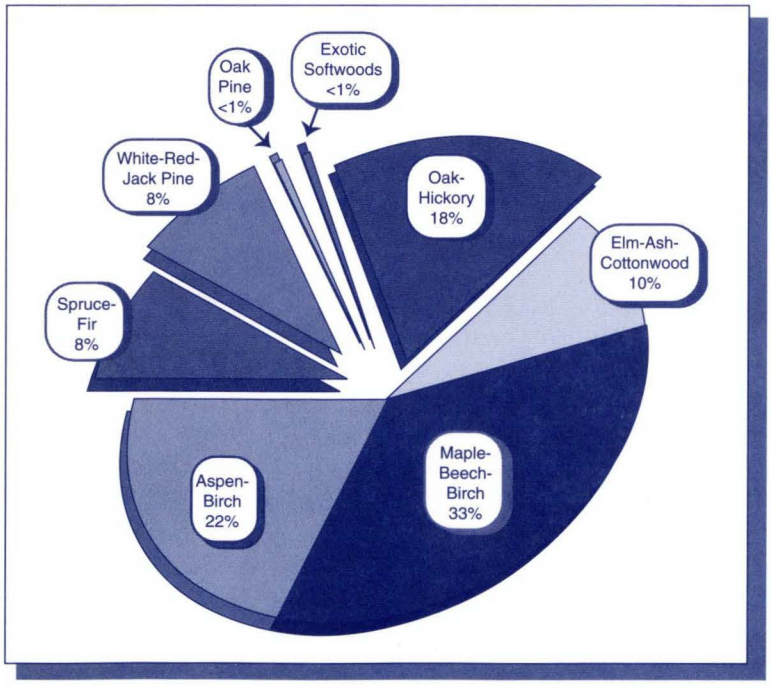

Figure 2.—*Area of timberland by forest type, Wisconsin, 2000.*

The area of timberland owned by the public has increased slightly since 1996. Publicly owned forests contribute critical wildlife habitat, outdoor recreation opportunities, and many other environmental and social benefits.

Wisconsin's timberland continued to mature between 1996 and 2000, resulting in more acres classified as sawtimber and fewer acres classified as poletimber or seedling-sapling (fig. 3). Historically, timber harvests in Wisconsin ranged from clearcutting to individual selection where single trees were harvested, but the entire stand was not removed. Each harvest method affects the future stand-size distribution among these three classes.

Along with the increasing area of sawtimber stand-size class, growing-stock volume increased between 1996 and 2000. Growing-stock volume is the amount of solid wood in trees greater than 5 inches d.b.h., from 1 foot above the ground to a minimum 4-inch top diameter. As the diameter and height of trees grow larger and the number of trees larger than 5 inches d.b.h. increases, the volume of growing stock also increases. The volume of both softwood and hardwood growing stock has increased in every inventory since 1956 (figs. 4 and 5). The increased volume is a reflection of increased tree size and stocking. Another factor that contributed to the increased volume was the conversion of some non-growing-stock trees (primarily those with rough form or with rotten portions in live trees) to growing stock because of improved quality.

Hard and soft maples together were the species group that had the greatest growing-stock volume in 2000. The second greatest volume was in oaks, followed by cottonwood and aspen, eastern white and red pines, other eastern hardwoods, and ash. Hardwoods dominated the State, accounting for just over 75 percent of the growing-stock volume. Public forests appear to have about the same volume per acre as privately owned forests.

In summary, it appears that stocking, stand-size class, and growing-stock volume have increased since the 1996 inventory while the area has decreased slightly. These first-year results are, overall, positive indications about the condition of Wisconsin's forests; we will learn more about these resources as we implement and complete annual inventories of the State over the next 4 years.

INVENTORY METHODS

Changes Between Inventories

Since the 1996 inventory of Wisconsin, several changes have been made in the NCFIA inventory methods to improve the quality of the inventory as well as meet the increasing demands for timely forest resource information. The most significant change between the inventories has been the change from periodic to annual inventory systems. Historically, the NCFIA inventoried each State on a cycle that averaged about 15 years. However, the need for timely and consistent data across large geographical regions, combined with national legislative mandates, resulted in NCFIA's implementation of an annual inventory system. The annual inventory system began in Wisconsin in 2000.

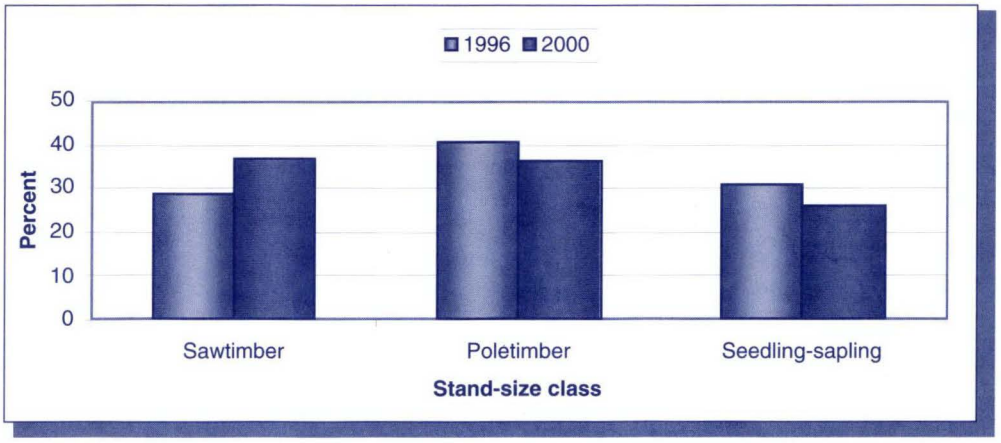

Figure 3.—*Stand-size classification as a percentage of total timberland area, Wisconsin, 1996 and 2000.*

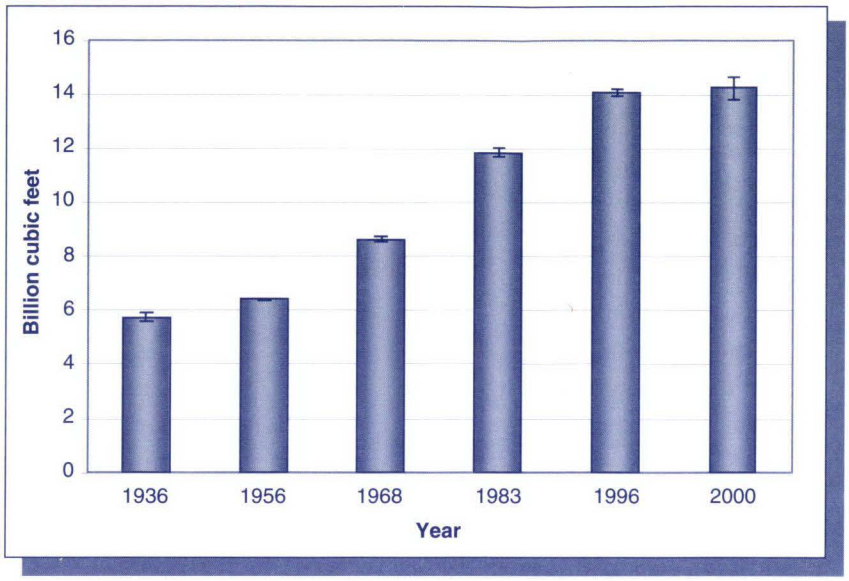

Figure 4.—*Hardwood growing-stock volume in Wisconsin by inventory year (Note: the sampling error associated with each inventory is represented by a vertical line at the top of each bar.)*

With an annual inventory system, approximately one-fifth of all field plots are measured in any single year. After 5 years, the entire inventory will be completed. After the initial 5-year period, NCFIA will report and analyze results as a moving 5-year average. For example, NCFIA will be able to generate inventory results for 2000 through 2005 or for 2001 through 2006. While there are great advantages for an annual inventory, one difficulty is reporting on results in the first 4 years. With the 2000 inventory, only 20 percent of all field plots have been measured. Sampling error estimates for the 2000 inventory are 1.39 percent for timberland area and 2.55 percent for growing-stock volume. Thus, caution should be used when drawing conclusions based on this limited data set. As ensuing measurements are completed, we will have additional confidence in our results because of the increased number of field plots measured. As each measurement year is completed, the quantity and quality of the results will expand.

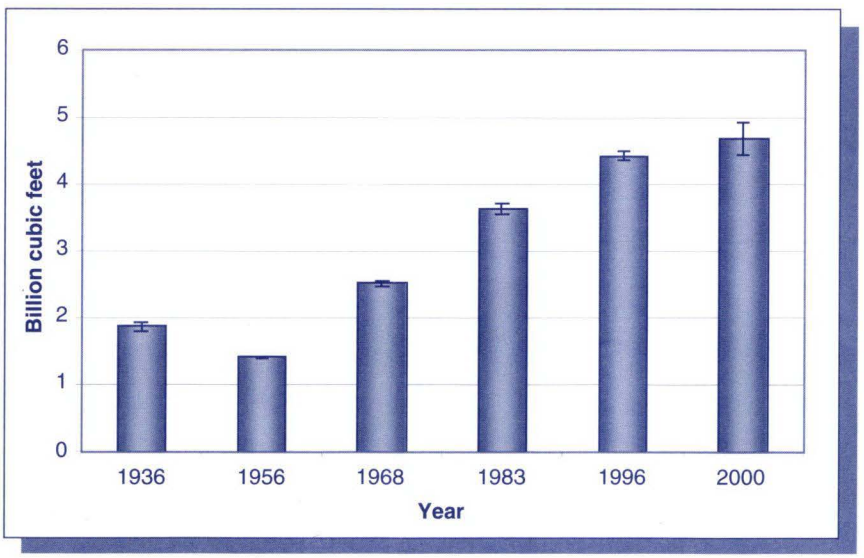

Figure 5.—*Softwood growing-stock volume in Wisconsin by inventory year (Note: the sampling error associated with each inventory is represented by a vertical line at the top of each bar.)*

Other significant changes between inventories include the implementation of new remote sensing technology, implementation of a new field plot design, development of new volume equations, and gathering of additional remotely sensed and field data. The use of new remote sensing technology since the previous inventory has allowed NCFIA to use computer-assisted classifications of Multi-Resolution Land Characterization (MRLC) data and other available remote sensing products to stratify the total area of the State and to improve estimates. Previous inventories used manual interpretation of aerial photographs to stratify the sample.

The new volume equations, developed by USDA Forest Service research scientists and other cooperating researchers, more accurately estimate the true growing-stock and sawtimber volumes. As additional annual inventories are implemented and comparisons between the current inventory and previous inventory become possible, FIA will update the 1996 inventory using the new volume equations.

New algorithms were used in 2000 to assign forest type and stand-size class to each condition observed on a plot. These algorithms are being used nationwide by FIA to provide consistency from State to State and will be used to reassign the forest type and stand-size class of every plot in the 1996 inventory when it is updated. This will be done so that changes in forest type and stand-size class will reflect actual changes in the forest and not changes due to algorithms. The list of recognized forest types, groupings of these forest types for reporting purposes, equations used to assign stocking values to individual trees, definition of nonstocked (stands with a stocking value of less than 10 percent for all live trees), and names given to the forest types changed with the new algorithms.

Another change with the current inventory is the determination of the exact plot location of every ground plot in the new inventory. For plots that are visited in the field, this is done using a global positioning system (GPS) device at plot center. For plots not visited in the field, the plot location is determined by transferring the old plot location from aerial photography to an unclassified, geo-corrected remotely sensed image. Both procedures provide an accurate location that is used to link the ground plots to the classified remotely sensed data used for stratification.

PROCEDURES

The 2000 Wisconsin survey used a two-phase sample for stratification that included remeasuring inventory plots from the 1996 inventory and new field plots. Two-phase sampling, also called double sampling, consists of a phase 1 sample used to estimate area by strata and a phase 2 sample used to estimate the average value of parameters of interest within the strata. The estimated population total is the sum across all strata of each stratum's estimated area multiplied by its estimated mean per unit area.

The only land that could not be sampled was private land where field personnel could not obtain permission to measure a phase 2 plot. These denied access plots were rare in Wisconsin (about 2 percent of the total plots statewide), and the methods used in the preparation of this report made the necessary adjustments to account for sites where access was denied.

Phase 1

Phase 1 and phase 2 plots were placed systematically across the entire State without regard to specific land characteristics. All lands have the same probability of being sampled under this inventory system. The 2000 inventory used a computer-assisted classification of satellite imagery for classification. FIA used the imagery to form two initial strata—forest and nonforest. Pixels within 60 m (2 pixel widths) of a forest/nonforest edge formed two additional strata—forest/nonforest and nonforest/forest. Forest pixels within 60 m of the boundary on the forest side were classified as forest/nonforest. Pixels within 60 m of the boundary on the nonforest side were classified into the nonforest/forest strata. An overlay of all national forest land was used to identify all lands owned by the Chequamegon and Nicolet National Forests. These national forest lands were treated separately but were also stratified into one of the above four strata. Stratification and estimation were conducted at the State level for national forest lands and at the FIA Inventory Unit level for other lands. Final estimation of area by stratum was based on these five strata—national forest, forest, forest/nonforest, nonforest/forest, and nonforest for all lands.

In the 1996 inventory, aerial photographs were assembled into township mosaics, and a systematic grid of 121 one-

acre photo plots (each plot representing approximately 190.4 acres on the ground) was overlaid on each township mosaic. Each of these photo plots was stereoscopically examined by aerial photo interpretation specialists and classified based on land use, forest type, and stand-size density. From these photo plots, a systematic sample of plots (without regard to their aerial photo classification) was selected as ground plots and further examined by survey crews to verify the classification and to make further measurements. These 1996 ground plots formed the basis for the remeasured ground plots in the 2000 inventory. Additional information related to the procedures for the 1996 inventory can be found in Schmidt (1998).

The move to satellite imagery changed NCFIA's phase 1 sample from being based on one photo plot for every 190.4 acres to a sample based on a classified pixel every 0.22 acres. The increased intensity of the phase 1 sample greatly improved estimates of the area within each stratum, particularly at the county level. Also, because the classification was conducted using a computer-assisted algorithm across the entire State, biases in the photo plot sampling method that resulted from differences in photo quality, age of photography, and experience of the photo interpreter were eliminated and classification was consistent across the entire State.

Phase 2

Phase 2 of the inventory consisted of the measurement of an annual sample of field plots in Wisconsin. Current FIA precision standards for annual inventories require a sampling intensity of one plot for every 5,937 acres. To satisfy this requirement, the geographical hexagons established for the Forest Health Monitoring (FHM) program were divided into 27 smaller NCFIA hexagons, each of which contained 5,937 acres (McRoberts 1999). A grid of field plots was established by selecting one plot from each of the smaller hexagons based on the following rules: (1) if an FHM plot fell within a hexagon, it was selected as the grid plot; (2) if no FHM plot fell within the hexagon, the existing FIA plot nearest the hexagon center was selected as the grid plot; and (3) if neither FHM nor existing NCFIA plots fell within the hexagon, a new NCFIA plot established near the hexagon center was selected as the grid plot (McRoberts 1999). This grid of plots is designated the Federal base sample and is considered an equal probability sample; its measurement in Wisconsin is funded by the Federal government. The State of Wisconsin supplemented the Federal base sample and doubled the number of sample plots across the State.

The total Federal base sample of hexagonal grid plots was systematically divided into five interpenetrating, non-overlapping subsamples or panels. Each year the plots in a single panel are measured and panels are selected on a 5-year, rotating basis (McRoberts 1999). For estimation purposes, the measurement of each panel of plots may be considered an independent random sample of all land in a State. Field crews measured vegetation on plots in the forested and straddler (nonforest/forest and forest/nonforest) categories; plots classified as non-forested were checked to ensure correct classification.

NCFIA has two categories of field measurements—phase 3 (formally FHM plots) and phase 2 field plots to optimize our ability to collect data when available for measurement. It is imperative that each type of plot be uniformly distributed both geographically and temporally. Phase 3 plots are measured with the full array of vegetative and health variables (Mangold 1998). Phase 3 plots must be measured between June 1 and August 30 to accommodate measurement of non-woody understory vegetation, ground cover, and other variables. We anticipate that in Wisconsin the complete 5-year annual inventory will involve about 160 phase 3 plots. On the remaining plots, only variables that can be measured throughout the entire year are collected. In Wisconsin, the complete 5-year annual inventory is expected to involve about 3,500 phase 2 forested plots and about 1,380 phase 2 straddler plots. With intensification, the number of field plots will be doubled.

The new national FIA 4-point cluster plot design was used for data collection (fig. 6) in 2000 and will be used in subsequent years. For all remeasured field plots in the Federal base sample, the new 4-point cluster plot was established and measured at the old plot (1996) location. In addition, the first five subplots of the old 10-point (subplot) cluster were also remeasured in 2000 to estimate change. All trees previously measured on these plots were remeasured or otherwise accounted for on these five subplots. These measurements form the basis for change estimates between the 1996 inventory for characteristics such as average annual net growth, mortality, and removals. Thus, until a complete

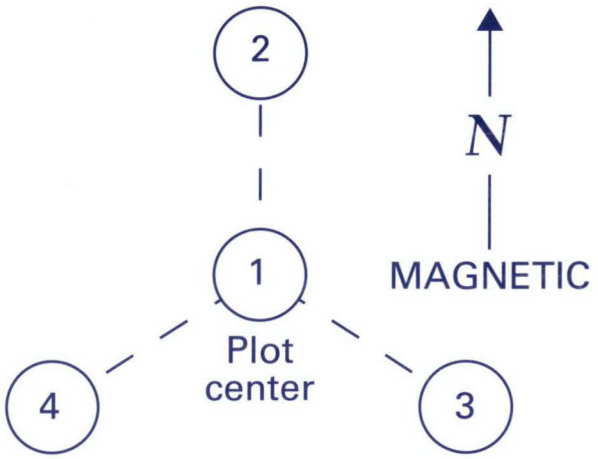

Figure 6.—*Current NCFIA field plot design.*

cycle of annual inventories for Wisconsin has been accomplished, both the new 4-point cluster plots and part of the old 10-point cluster plots will be measured. If the anticipated 20-percent of the State is sampled each year, by the sixth year of annual inventories in Wisconsin, the new 4-point cluster plots will begin to be remeasured and the former plot design will be abandoned. The national plot design also requires mapping forest conditions on each plot. Due to the small sample size (20 percent) each year, the precision associated with change factors such as mortality will be relatively low. Consequently, change estimates will not be reported until at least three annual inventories have been completed, and even then we anticipate that estimates of change will be limited in detail. When the complete annual inventory has been implemented in 2005, the full range of change variables will be available.

The overall plot layout for the new design consists of four subplots spaced 120 feet apart in a triangular arrangement. Subplots 2, 3, and 4 are spaced 120 degrees apart. The center of the new plot is located at the same point as the center of the previous plot if a previous plot existed within the sample unit. All trees less than 5.0 inches in diameter at breast height (d.b.h., or 4.5 feet above ground level) are measured on a 6.8-foot radius (1/300 acre) circular microplot located 12.0 feet due east of the center of each of the four subplots. Trees with diameters 5 inches and larger are measured on a 24-foot radius (1/24 acre) circular subplot. The forest condition of each subplot is recorded. Factors that can determine a change in forest condition from subplot one are changes in forest type, stand-size class, land use, ownership, and density. Each condition that occurs anywhere on one of the subplots is identified, described and mapped if the condition in total meets or exceeds one acre in size (the one acre minimum size for a condition to be identified could include land off the subplot). Each condition is assigned a condition number and condition information is recorded.

Field plot measurements are combined with phase 1 estimates in the compilation process. As additional annual inventories are completed, tables will be generated for publication. In year 5, all statewide inventory summary tables will be available in both printed and electronic formats. For additional information, contact:

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LITERATURE CITED

Mangold, R.D. 1998. Forest health monitoring field methods guide (National 1998). Research Triangle Park, NC: U.S. Department of Agriculture, Forest Service, National Forest Health Monitoring Programs. 429 p. (Revision 0, April 1998).

McRoberts, R.E. 1999. Joint annual forest inventory and monitoring system, the North Central perspective. Journal of Forestry. 97(12): 27-31.

Schmidt, T.L. 1998. Wisconsin's forest statistics, 1996. Resour. Bull. NC-183. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 150 p.

Smith, W.B.; Vissage, J.S.; Darr, D.R.; Sheffield, R.M. 2001. Forest resources of the United States, 1997. Gen. Tech. Rep. NC-219. St. Paul, MN. U.S. Department of Agriculture, Forest Service, North Central Research Station. 190 p.

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